V.3.3-ADJUST-Q ADJUST SIMULATED DISCHARGE OPERATION

Identifier: ADJUST-Q

Application: All programs

Description: This Operation adjusts simulated instantaneous discharge at a flow point to agree as close as possible with observed discharge data.

In the Calibration System programs, the simulated hydrograph at an upstream flow point should be adjusted by observed data before routing downstream to calibrate downstream local areas. The ideal approach would be to route the actual observed instantaneous discharge. In this way the volume and timing errors in the simulation would not be propagated downstream. However, complete records of observed instantaneous discharge are seldom available. Thus, the next best approach is to route simulated discharge that has been adjusted by observed daily discharge and any available instantaneous flow data.

In the Operational Forecast System programs, the Operation is used to update the simulated hydrograph with observed data and blend between the last observed value and future simulated discharges before making forecasts and before routing downstream to forecast downstream points.

The two types of observed data used by the Operation are instantaneous discharge and mean daily discharge. Generally, only instantaneous data are available operationally, whereas for calibration, only mean daily data are usually available. If no discharge observations are available during the period of the run, no adjustments to simulated discharge are made.

The following describe the adjustment procedure when using each type of data.

Adjustment Procedure Using Mean Daily Discharge (MDQ)

The objective of this procedure is to adjust simulated instantaneous flow so that the resulting MDQ value is within a certain percentage of the observed MDQ value for each day that has an observed value. The computation of a simulated MDQ requires a full complement of instantaneous values, i.e., a value for each data time interval ordinate during the day. If the run begins in the middle of a day, carryover discharge values are used to complete the discharge array for the first day. If the run ends in the middle of a day, a simulated MDQ cannot be computed and consequently no adjustments based on MDQ ratios are made to the discharge values of the last day.

Simulated instantaneous discharge values for each day are adjusted by the ratio of observed to simulated MDQ as follows:

$$Qi = Qi * QME/SQME \quad (1)$$

where QME is the observed MDQ
SQME is the simulated MDQ
Qi is the instantaneous discharge

The error tolerance, expressed as a decimal fraction, for comparing the observed and simulated MDQ values is a parameter for the Operation. When the run begins in the middle of a day, the tolerance for the first day is increased as follows:

$$Ta = Ti + (NP-NS)/NP \quad (2)$$

where Ta is the adjusted tolerance
Ti is the tolerance parameter
NP is the total number of ordinates in the day
NS is the number of adjusted ordinates

This prevents the procedure from adjusting only a portion of the day's discharge for the volume error of the total day. Hour 24 values are given special treatment since each hour 24 discharge is the last value to be adjusted on a given day as well as the first value to be adjusted on the following day. The final adjusted hour 24 values are obtained by averaging the two adjustments. In this way continuity is maintained between successive days.

The adjustment process continues until each simulated MDQ is within the tolerance limits of its corresponding observed MDQ or a maximum of 15 iterations is reached. In the latter case, a warning message is issued and the current adjusted values at the time of termination are returned as the final adjusted values.

Adjustment Procedure Using Observed Instantaneous Discharge

As stated earlier, the ideal approach is to route the actual observed instantaneous discharge, but complete records are seldom available. One method of completing the record would be to interpolate between observed ordinates to obtain values at the required data time intervals. A better approach and the one used herein, is to use the simulated values, suitably adjusted by the observed data, as estimates of discharge at ordinates for which there are no observed values. The adjustment factor for each intermediate simulated ordinate is obtained by linearly interpolating between either the ‹ratios' or the ‹differences' between observed and simulated discharge at the observed ordinates. When based on ratios, the adjustment is applied as follows:

$$Qi = Qi * AFI \quad (3)$$

or when based on differences:

$$Qi = Qi + AFI \quad (4)$$

where Qi is the simulated instantaneous discharge
AFI is the adjustment factor for the ordinate

The use of either ratios or differences to make the adjustments is a user option with one exception when ratios are used. If at anytime the ratio at either of two tandem observed ordinates is greater than 5.0 or the ratios differ by more than a factor of 2.0, the program automatically switches to differences for interpolating the adjustment factors between the two observed ordinates in question. This measure prevents drastic adjustments from being made when a ratio is excessively large.

When instantaneous data are available infrequently or only for selected events during the run period, there may be sizeable gaps between observed values. In such cases it is not reasonable to interpolate between such widely spaced observed data values to make adjustments to the simulated values in between. Therefore, before interpolating, the distance between the two observations is checked. If it is less than STEPS, interpolation as described earlier is used; if it is greater, the difference between observed and simulated discharge at the first of the two observed ordinates is blended forwards into the subsequent STEPS simulated values and the difference at the second observed ordinate is blended backwards into the preceding STEPS simulated values. With this strategy, simulated discharge at ordinates further than STEPS from an observed value are not adjusted and the simulated value is thus used as the best estimate of discharge at that point. STEPS is defined in the section describing the blend routine.

Adjustment Procedure Using Both Instantaneous and Mean Daily Discharge Data

When both types of observed data are available, the adjustment process combines the two individual adjustment procedures. First, the simulated discharge is adjusted by the instantaneous flow data. Then mean daily discharge volumes are computed from the adjusted discharge values and compared with the observed MDQ volumes. If the MDQ's are not within the specified tolerance, adjustments as described in the MDQ procedure are initiated.

Blend Routine

As mentioned earlier, a blend is used within the instantaneous adjustment procedure when the observed values are too far apart for interpolation. In order to effect a smooth transition between the adjusted and unadjusted portions of the hydrograph, a blend is also performed following the last observation of the run and, on occasion, prior to the first observation of the run. The blend is performed prior to the first observation only when the distance between the final observation of the previous run and the first observation of the current run is large enough to preclude the use of the interpolation procedure. The period of the blend is a user parameter called STEPS. STEPS represents the maximum distance that the user feels is reasonable for extrapolating the information in an observed data value and hence, at which point the best estimate of discharge becomes the simulated value. See Section IX.3.3B-BLEND for a description of the blend procedure.

Carryover

Carryover for the Operation consists of the simulated instantaneous discharge values for the entire day (2400 to 2400) of the carryover date and the three following quantities: 1) the difference (MDQ) between the observed and simulated discharge at the last observed ordinate prior to the carryover date, 2) the number of ordinates (NB) between the last observed ordinate and the carryover date and 3) the observed discharge value (QB) at the last observed ordinate prior to the carryover date. If the last observed ordinate occurs more than STEPS prior to the carryover date, the last three carryover values are set equal to zero.

Allowable Data Time Intervals: 1, 2, 3, 4, 6, 8, 12 and 24 hours

Time Series Used: Time series used in this Operation are as follows:

General Type	Dimn	Units	Use	Required	Form of Output T.S.	Data Time Interval	Missing Values Allowed
Simulated Instantaneous Discharge	L3/T	CMS	I	yes	n/a	any	no
Adjusted Instantaneous Discharge	L3/T	CMS	O	yes	replace	any 1/	no
Mean Daily Discharge	L3	CMSD	I	no	n/a	24	yes
Observed Instantaneous Discharge	L3/T	CMS	I	no	n/a	any 2/	yes

1/ Must be the same as the data time interval for simulated instantaneous discharge.

2/ Must be an integer multiple of the data time interval for simulated instantaneous discharge.

Input Summary: The card input for this Operation is as follows:

Card	Format	Columns	Contents
1	5A4	1-20	Name of flow point
	I5	21-25	Use observed instantaneous discharge time series: 0 = no 1 = yes
	I5	26-30	Use observed mean daily discharge time series: 0 = no

Card	Format	Columns	Contents
			1 = yes
	I5	31-35	Read in carryover values: 0 = no - use default carryover values 1 = yes

Card 2 is needed only if an observed instantaneous discharge time series is used.

2	2A4	1-8	Internal identifier for observed instantaneous discharge time series
	3X,A4	12-15	Data type code for above time series
	I5	16-20	Data time interval for above time series (must be an even multiple of the simulated instantaneous discharge time series)

Card 3 is needed only if an observed mean daily discharge time series is used.

3	2A4	1-8	Internal identifier for observed mean daily discharge time series
	3X,A4	12-15	Data type code for above time series
4	2A4	1-8	Internal identifier for simulated instantaneous discharge time series
	3X,A4	12-15	Data type code for above time series
	I5	16-20	Data time interval for above time series (computational time interval for the Operation)
5	2A4	1-8	Internal identifier for adjusted instantaneous discharge time series
	3X,A4	12-15	Data type code for above time series (the time interval for this time series is the same as the simulated instantaneous discharge time series)
6	I5	1-5	Number of steps for blending; must be greater than zero

Next entry needed only if observed mean daily discharge is used.

	F10.3	6-15	Error tolerance (expressed as a decimal) for comparing simulated and observed mean daily discharge volumes; default is 0.025

Card	Format	Columns	Contents

Card 7 is needed only if observed instantaneous discharge is used.

7	I5	1-5	0 = Adjustments based on ratios of observed to simulated discharge 1 = Adjustments based on differences between observed and simulated discharge

Next 2 cards not needed if default carryover values used.

8	7F10.1	1-70	Simulated instantaneous discharge values from last day of previous run; must begin and end with hour 24 values; repeat card as needed to read in all values
9	F10.2	1-10	Difference between observed and simulated discharge at last observed ordinate of previous run
	I5	11-15	Number of ordinates between last observed and last computed ordinate of previous run
	F10.2	16-25	Observed instantaneous discharge value at last observed ordinate of previous run

If entry 2 on Card 9 is greater than or equal to entry 1 on Card 6 all three values on Card 9 should be read in as zero.

Sample Input and Output: Sample input is shown in Figure 1. Sample output from the parameter print routine is shown in Figure 2. There is no execution routine output.

Error and Warning Messages: The error and warning messages generated by this Operation and the corrective action to take when they occur are as follows:

A. Messages that can occur during setup:

1. **ERROR** NO OBSERVED DISCHARGE, INSTANTANEOUS OR MEAN DAILY, IS AVAILABLE. THEREFORE, NO ADJUSTMENTS CAN BE MADE.

   Action: Check to see that at least one type of observed discharge time series has been defined.

2. **ERROR** THE TIME INTERVAL OF THE OBSERVED INSTANTANEOUS TIME SERIES MUST BE AN EVEN MULTIPLE OF THE TIME INTERVAL OF THE SIMULATED TIME SERIES.

Action: Redefine the time interval of the observed instantaneous discharge time series if necessary.

3. **ERROR** THE NUMBER OF BLENDING STEPS (STEPS) CANNOT BE EQUAL TO ZERO.

   Action: Changes STEPS to a positive non-zero integer value.

4. **WARNING** ONE OR MORE CARRYOVER VALUES WERE NEGATIVE. THE VALUES WERE CHANGED TO ZERO.

   Action: If zero values not acceptable, read in positive carryover discharge values.

B. Messages that can occur during execution:

1. **WARNING** ADJUSTMENTS WERE STOPPED AFTER 15 ITERATIONS - ERROR WAS NOT REDUCED TO THE TOLERANCE LEVEL.

   Action: The user may want to make manual adjustments to the adjusted hydrograph before routing downstream.

C. Messages that can occur during carryover transfer:

1. **WARNING** NEITHER THE OLD (XXHOURS) NOR THE NEW (XXHOURS) SIMULATED DISCHARGE TIME SERIES TIME INTERVAL IS AN EVEN MULTIPLE OF THE OTHER. NO CARRYOVER VALUES CAN BE TRANSFERRED.

   Action: If default values are not acceptable, change the new time interval so that the old and new intervals are multiples of each other.

Carryover Transfer Rules: The following rules apply to this Operation during the carryover transfer process.

If the new simulated discharge time series time interval (△Tnew) is not equal to the old simulated discharge time series time interval (△Told) and

1. if △Tnew is a multiple of △Told, the instantaneous discharge carryover values are adjusted by selecting values from the old carryover discharge at △Tnew intervals

2. if △Told is multiple of △Tnew, the instantaneous discharge carryover values at △Tnew intervals are obtained by linearly interpolating between the old carryover values.

3. if neither △Tnew nor △Told is a multiple of the other, no instantaneous discharge carryover is transferred

The three carryover values associated with the last observed ordinate prior to the carryover date, i.e., MDQ, NB and QB, are transferred as follows:

1. if either the old or the new parameter set does not specify instantaneous discharge data, all three values are set equal to zero

2. if the length of the new blend period in hours is less than or equal to the portion of the old blend completed (NB) in hours, all three values are set equal to zero

3. otherwise, MDQ and QB are transferred directly and NB is adjusted by the ratio of △Told to △Tnew

Punched Card Limitations: The punched card formats for this Operation are as follows:

Parameters or Variables	Punched Format	Maximum Value	Minimum Value	Precision After Decimal Point
NSTEPS	I5	10000	1	n/a
Error tolerance	F10.3	999999.999	.001	thousandths
Instantaneous discharge carryover	F10.1	99999999.9	.1	tenths
MDQ	F10.2	9999999.99	.01	hundredths
NB	I5	10000	0	n/a
QB	F10.2	9999999.99	.01	hundredths

No checks are made for values greater or less than the maximum and minimum values.

Figure 1. Sample Card Input For Operation ADJUST-Q

```
                                    - Column -
    5   10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+----+

ADJUST-Q    ANMWE
SILVERTON R-ANIMAS      1    0    0
ANMWE      QIN     6
ANMWE      SQIN    6
ANMWE      QINE
 1000
    1
```

Figure 2. Sample Output From Operation ADJUST-Q Print Parameter Routine

```
********************

ADJUST-Q OPERATION     NAME=ANMWE        PREVIOUS NAME=

********************

          ADJUST OPERATION FOR SILVERTON R-ANIMAS  . SIMULATED INSTANTANEOUS DISCHARGE
          IS ADJUSTED BY AVAILABLE OBSERVED DISCHARGE DATA.

          TIME SERIES USED:         ID                 TYPE              TIME(HR)
                                     ANMWE              SQIN               6
                                     ANMWE              QINE               6
                                     ANMWE              QIN                6

          ONLY OBSERVED INSTANTANEOUS DISCHARGE DATA ARE AVAILABLE.

          COMPUTATIONAL TIME INTERVAL FOR THE OPERATION =  6 HOURS.

          NUMBER OF PERIODS USED TO BLEND = 1000.

          ADJUSTMENTS USING INSTANTANEOUS OBS. DATA BASED ON DIFFERENCES BETWEEN OBS. AND SIM.
            DISCHARGE.

          DEFAULT CARRYOVER VALUES ARE USED. ALL VALUES ARE INITIALLY EQUAL TO 0.0
```